95-G-050

July 1997

Baseline Evaluation of Performance, Workload and Situation Awareness in the Current Air Traffic Control System

Mica R. Endsley
Debra G. Jones
S. Armida Rosiles
Texas Tech University
Lubbock, TX

Carol A. Manning
Henry Mogilka
Faith Arnell
Federal Aviation Administration
Oklahoma City, OK

Introduction

The National Air Traffic Control system in the United States is in a period of transition. Many new technologies, for instance GPS and TCAS, have been introduced which may create a change in the way that controllers perceive air traffic, and may allow significantly different ways of doing business (e.g. Free Flight). In addition, the equipment that controllers work with is being replaced with newer technology, and proposals to add significant new capabilities through automation remain under consideration.

Each of these changes has the potential of significantly changing controllers' understanding of the air traffic situation, experienced workload and performance in managing the air traffic. While many of these new concepts are touted as potentially improving controller performance through a reduction in workload, it is also possible that they may act to compromise controllers' ability to control traffic through a reduction in situation awareness. For instance, changes in the dynamics and predictability of aircraft which may occur as a result of Free Flight conditions may reduce controllers' ability to understand the significance of aircraft actions and predict future separation problems (Endsley, Mogford, Allendoerfer, & Stein, 1997). Automation of functions, which is generally thought to reduce workload, has also been found to create low situation awareness leading to out-of-the-loop performance problems (Endsley & Kiris, 1995a). There is also increasing evidence that automation frequently results in workload levels that are not reduced due to increases in monitoring demands (Endsley, 1995b). Even subtle changes in the way that information is displayed or the way that tasks are carried out may have an impact on situation awareness, workload and performance in controlling traffic.

This possibility creates the strong need for each change to be carefully evaluated prior to implementation in the National Airspace System (NAS) in order to insure that air safety is maintained at all times. A clear understanding of the actual effects of potential system changes is critical to the proper design and selection of new technologies and procedures. In this way modifications to the technologies, displays or procedures can be developed and implemented to compensate for any problems before they lead to diminished air safety.

In order to effectively test new concepts, it is first necessary to establish exactly what current levels of controller workload, situation awareness and performance are within today's Air Traffic Control system. By comparing these factors between today's system and proposed system concepts, the effects of new concepts under consideration (either good or bad) can be established. Unfortunately, little data exists regarding workload and situation awareness during normal operations in today's system. While some data exists regarding controller performance (in terms of operational errors, for instance), most of this information is at a very high level and does not provide sufficient sensitivity to allow concepts to be evaluated. As so few operational errors tend to occur, it is unlikely that a sufficient number would take place during the limited conditions of design testing to allow even major problems with a concept to be detected in a statistically significant manner. In addition, it is difficult to determine more detailed, agreed-upon measures of performance for ATC. For this reason, sensitive indices of controller capability and performance are needed.

Objective

The objective of the present study was to establish a benchmark for controller situation awareness, workload, and performance with the current air traffic control system using available metrics. This information will be used to provide input into the process of evaluating the viability of proposed system modifications in order to insure that a high level of flight safety is maintained.

Method

Subjects

Thirteen participants served as controllers in this study on a voluntary basis. Each was an active or retired Full Performance Level (FPL) Air Traffic Control Specialist (ATCS). Mean years of experience in ATC was 18.1 with a mean of 12.8 years at FPL. Mean time since actively controlling traffic was 3.3 years. There were 10 males and 3 females included in the study.

Equipment

The simulator at the Mike Moroney Air Traffic Control Academy served as the testbed for this study. The simulator includes a duplicate of the radar display, controls and flight strips that are used in the field today. In addition to the test participant, confederates served as the controller for adjoining sectors, and to control the pseudo-pilot stations. A Macintosh computer running Hypercard stacks was used to collect workload and situation awareness data.

Four en route air traffic scenarios were created to serve as test scenarios for this study and future studies which wish to compare new ATC concepts to the existing air traffic system. Two of these scenarios involved Aero Sector (Scenario 4 - low traffic and Scenario 5-high traffic) and two involved Tulsa high altitude sector (Scenario 1-low traffic and Scenario 3-high traffic). Each air traffic scenario was approximately 30 minutes long. The scenarios were developed by FPL ATCS instructors at the Mike Moroney Air Traffic Control Academy. The scenarios were created to include varying levels of air traffic, separation problems, airspace conflicts (both with sector boundaries and special airspace), point-outs and hand-offs, pilot conformance problems, pilot communications and poor weather situations. The low altitude scenarios involved arrival sequencing and departure flows.

Experimental Design

Each participant controlled traffic in each of the four scenarios. Scenarios were administered in a (partially) counter-balanced order across two three-hour blocks. The two high altitude scenarios were blocked as were the two low altitude scenarios. The two scenarios of each type were presented in a counter-balanced order across subjects and the two types of scenarios were presented in counter-balanced order across subjects.

Dependent Variables included:

(1) Performance -

- Subjective Evaluation - A subjective evaluation of controller performance was completed by a subject matter expert (SME) at the end of each scenario. The SME was an experienced controller currently serving as an instructor at the FAA Academy. This form included a three point rating of controller performance in each of several categories: Separation, control judgment, methods and procedures, equipment, communication and coordination. It is shown in Appendix A. The form was based on that currently used in air traffic control centers for on-the-job evaluations by supervisors (FAA Form 3120-25).

- Remaining Actions - As a second measure of controller performance, the number of actions that were remaining in order for the controllers to complete the scenarios (get all aircraft through the sector) at the designated end of the scenario were tallied. Remaining actions include altitude changes, speed changes, initiating hand-offs and accepting hand-offs, giving approach or departure clearances, making frequency changes and rejecting or delaying a hand-off or departure. This form was also completed by the SME at the end of each scenario. It is shown in Appendix B. The form is based on that used by Vortac, Edwards, Fuller, and Manning (1993).

(2) Workload - The NASA Task Load Index (NASA-TLX) (Hart & Staveland, 1988) served as a subjective measure of workload. NASA TLX ratings were obtained

from each of the participants on a bipolar scale and weighted based on each subject's rankings of the TLX component factors to produce an overall workload rating. This form is shown in Appendix C.

(3) Situation Awareness - The Situation Awareness Global Assessment Technique (SAGAT): ATC Version (Endsley & Kiris, 1995b) was used to measure participant SA during the test. Four randomly placed freezes were inserted into each trial to collect SAGAT data. Each of the following SAGAT queries were administered at each stop (Shown in Appendix D.)

- Level 1 SA - Perception of the Traffic Situation
    - Aircraft Location
    - Aircraft Level of Control
    - Aircraft Callsign
    - Aircraft Altitude
    - Aircraft Groundspeed
    - Aircraft Heading
    - Aircraft Flight Path Change (vertical, turning)
    - Aircraft Type

- Level 2 & 3 SA - Comprehension & Projection of Traffic Situation
    - Aircraft Next Sector
    - Activity in Sector
    - Aircraft Separation
    - Aircraft with New Clearance
    - New Clearance Received Correctly
    - Aircraft Conformance to Clearance
    - Aircraft Hand-offs
    - Aircraft Communications
    - Special Airspace Violations
    - Approach Clearance Needed
    - Conforming to Flight Plan

Procedure

Each participant was provided with a set of instructions and informed consent form to sign prior to participation in the study (shown in Appendix E). In addition to receiving information on their role in the study, they also received instructions on filling out the SAGAT and NASA-TLX rating forms. They then were provided with a practice air traffic scenario which was interrupted after 5 to 10 minutes to fill out SAGAT and NASA-TLX. They were allowed to ask questions to clear up any problems they had in understanding the questionnaires or the simulation.

At the beginning of each scenario, the SME provided a position relief briefing to the participant as if he or she were assuming control in an active air traffic sector. The participant was then free to control traffic to the best of his or her ability using whatever strategies or tactics they normally used.

At four randomly determined points during each scenario, the simulation was frozen to collect SAGAT and NASA-TLX data. At the time of the freeze, the radar screen was blanked and the simulation was paused while the participant completed the SAGAT queries. Participants first were provided with a map of the sector which showed only boundaries and navigation fix points. They were asked to indicate where all aircraft in the sector were on the map (for all aircraft currently under their control, in their sector boundaries but recently handed-off, and for those aircraft soon to be in their control). The remaining queries were then asked in random order in relation to the aircraft the participants indicated were present (see Appendix D).

At the same time that participants filled out the SAGAT battery, the SME filled out a SAGAT data collection form (while viewing the frozen radar screen and flight strips) in order to supplement the data collected by the simulation computer (see Appendix F). Participants completed all SAGAT queries and then the NASA-TLX workload rating form, following which they returned to the simulation at the point where they left off. They were given a few seconds to observed the radar screen prior to unfreezing the scenario to resume the simulation. At the end of each trial the SME filled out the subjective performance form and remaining actions form.

Results and Discussion

Descriptive statistics are provided for each of the four scenarios for later comparison to simulations involving NAS concept or equipment changes with the same scenarios. In addition, statistical analyses of the data were conducted using one-way analyses of variance (ANOVAs) to examine differences between the four scenarios (unless otherwise noted). F-values are reported if a significant main effect of condition was found. Post-hoc, pair-wise comparisons were conducted using a Tukey test. An alpha level of .05 was used for all statistical tests. Some data were lost due to problems with data recording and were omitted from the analysis.

The performance measures for each scenario, in terms of the mean and variance, are presented in Table 1. As shown, a significantly higher number of aircraft were still remaining to be processed in scenarios 3 and 5 (the high traffic scenarios), as compared to scenarios 1 and 4 (the low traffic scenarios). All participants had the same number of aircraft remaining at the end of each scenario, therefore there was no variance for this measure. Significantly more actions were remaining at the end of scenarios 3 and 5, as compared to scenarios 1 and 4, $F(3,48)=191.43$, $p<.001$. When the uneven number of aircraft remaining between scenarios is accounted for, there were still significantly more actions remaining per aircraft in scenarios 3 and 5, $F(3,48)=31.95$, $p<.001$. This serves to help verify that scenarios 3 and 5 were higher traffic volume, more difficult scenarios than 1 and 4. No significant differences were observed between the low traffic scenarios from the two different sectors or the high traffic scenarios from the two different sectors.

The SME subjective evaluations of the controllers' performance showed no significant differences between scenarios ($\chi^2 = 6.86$) at the .05 level. As shown in Table 1, there were very few unsatisfactory or needs improvement ratings made across the 26

Table 1. Performance in Each Scenario
Mean (Variance)

	High Altitude		Low Altitude	
	Scenario 1	**Scenario 3**	**Scenario 4**	**Scenario 5**
Total Remaining Actions	**19.15** (2.64)	**45.46** (7.10)	**21.31** (11.90)	**38.15** (23.14)
Aircraft at End of Scenario	**17.0** (0)	**32.0** (0)	**18.0** (0)	**23.0** (0)
Remaining Actions/Aircraft	**1.13** (.01)	**1.42** (.01)	**1.18** (.04)	**1.66** (.04)
SME Evaluation (number of unsatisfactory or needs improvement ratings)	**6**	**11**	**4**	**9**

factors in the rating form across the 13 subjects. Although not statistically significant, the trend supports the contention that scenarios 3 and 5 were more difficult than scenarios 1 and 4.

Participants rated their subjective level of workload at each of the four simulation freezes using the NASA-TLX rating forms. These ratings were weighted based on each participants' workload component rankings. The means and variance of the NASA-TLX ratings for each scenario are shown in Table 2. As shown, the participants rated scenarios 4 and 5, the two low altitude scenarios, as significantly less difficult than the two high altitude scenarios, $F(3,203) = 3.221$, $p=.02$. There were no significant differences between the workload ratings for the high and low traffic volume scenarios of each sector type, however. This finding is in agreement with other observations of dissociation between workload and performance (Yeh & Wickens, 1988).

Participants' responses to each of the SAGAT queries were compared to the correct response for each query based on data collected by the simulation computer or SME (while looking at the radar screen and flight strips) at the time of each freeze. The

Table 2. NASA-TLX Workload Ratings for Each Scenario
Mean (Variance)

	High Altitude		Low Altitude	
	Scenario 1	**Scenario 3**	**Scenario 4**	**Scenario 5**
NASA-TLX Rating	**41.41** (471.60)	**46.39** (596.44)	**33.21** (499.07)	**35.80** (653.08)

responses were then scored as correct or incorrect. Mean percent correct (and variance) are shown for each query across the four scenarios in Table 3.

There were differences in controller Level 1 SA (perception of the situation) on several variables. Participants were aware of fewer aircraft in the two high altitude sectors (1 and 3) than the low altitude sectors, $F(3,195)=5.78$, $p=.001$. This is in agreement with the finding of higher workload for those sectors. For those aircraft participants were aware of, a rather mixed picture emerged of their situation awareness.

The initial alphabetic portion of the aircraft callsigns was scored separately from the numeric portion. Participant's were aware of significantly more of the alphabetic portion of the callsigns in the two low altitude sectors, $F(3,194)=5.59$, $p=.001$.

Awareness of the numeric portion was low overall and not significantly different between scenarios. Similarly, awareness of aircraft altitude and heading was not significantly different between scenarios, and there was no difference between scenarios in awareness of whether aircraft were turning.

Subjects were aware of aircraft speed significantly more often in Scenario 3 (high altitude sector, high traffic load) and significantly less often in Scenario 5 (low altitude sector, high traffic load) than in the other two scenarios, $F(3,203)=7.76$, $p<.001$. They were also significantly more aware of the level of control they had over aircraft in Scenario 5 and less in Scenario 3, $F(3,193)=5.63$, $p=.001$. These findings are rather at odds with each other and with prior findings.

Table 3. Situation Awareness Responses in Each Scenario
% Correct (Variance)

	High Altitude		Low Altitude	
	Scenario 1	Scenario 3	Scenario 4	Scenario 5
Aircraft Location	35.5% (1.9)	32.8% (2.1)	37.7% (2.4)	44.1% (2.0)
Callsign: Alphabetic	10.6% (9.7)	21.2% (17.0)	41.7% (24.8)	39.2% (24.3)
Callsign: Numeric	6.4% (6.1)	11.5% (10.4)	6.3% (6.0)	2.0% (2.0)
Altitude	14.6% (12.7)	21.2% (17.0)	15.7% (13.5)	7.1% (6.8)
Speed	31.3% (21.9)	51.9% (25.5)	23.5% (18.4)	12.5% (11.1)
Heading	64.6% (23.4)	50.0% (25.5)	51.0% (25.5)	57.1% (24.9)
Next Sector	48.8% (25.6)	56.1% (25.2)	72.7% (20.3)	55.6% (25.3)
Vertical Change	84.8% (13.2)	65.4% (23.1)	50.0% (25.5)	51.9% (25.5)
Turning	76.1% (18.6)	67.3% (22.4)	68.8% (21.9)	63.5% (23.6)
Aircraft Type	26.1% (19.7)	17.3% (14.6)	8.3% (7.8)	5.8% (5.5)
Level of Control	70.4% (3.9)	62.1% (5.3)	66.3% (4.8)	77.2% (1.3)
Activity in Sector	93.0% (6.6)	53.7% (25.5)	40.9% (24.7)	35.6% (23.4)
Separation	97.1% (2.9)	82.8% (13.9)	88.6% (10.4)	79.9% (13.9)
Aircraft with New Clearances	32.3% (19.2)	22.9% (13.5)	48.2% (19.5)	51.8% (14.2)
Clearance Received Correctly	40.0% (24.8)	28.6% (20.9)	71.4% (21.0)	76.7% (17.9)
Conforming to Clearance	40.0% (24.8)	28.6% (20.9)	68.6% (22.2)	75.4% (18.6)
Aircraft Needing Handoffs	69.0% (18.0)	44.8% (20.2)	50.2% (22.1)	42.5% (22.1)
Aircraft in Communication	43.9% (19.0)	32.4% (14.4)	54.2% (17.5)	50.0% (19.6)
Airspace Violations	95.7% (4.3)	95.8% (4.1)	100.0% (0.0)	92.3% (7.2)
Approach Clearance Needed	100.0% (0.0)	79.2% (16.8)	75.2% (13.3)	61.2% (13.1)
Conforming to Flight plan	50.0% (24.4)	70.5% (21.3)	68.9% (21.9)	65.3% (23.1)

Subjects were significantly more aware of changes in aircraft altitude (climbing or descending) in the high altitude sectors than the low altitude sectors, $F(3,194)=5.54$, $p=.001$, and more so in Sector 1 than Sector 3. Participants were also significantly more aware of aircraft type in the two high altitude sectors, $F(3,194)=3.50$, $p=.017$. This is opposite the other findings of higher workload and lower awareness of aircraft location for the high altitude sectors, demonstrating trade-offs in awareness between SA elements. Likely a reflection in changes in controllers' attention, this type of trade-off has also been found in other studies of SA (Endsley, 1995a; Endsley & Rodgers, 1996).

Several of the queries related to the higher levels of situation awareness (comprehension and projection) were also different between conditions. Participants were significantly more aware of the activity the aircraft were performing in the sector (en route, in-bound from airport or out-bound from airport) in the high altitude sectors and particularly so in Scenario 1 (low traffic volume), $F(3,169)=14.60$, $p<.001$. They were significantly more aware of aircraft with active clearances in the low altitude sectors, however, $F(3,160)=4.62$, $p=.004$. They were the least aware of aircraft with active clearances in Scenario 3 (high altitude, high traffic volume). Of those aircraft they indicated had an active clearance, participants' were more accurate in reporting whether the aircraft had received the clearance correctly, $F(3,151)=10.93$, $p<.001$, and were conforming to that clearance, $F(3, 151)=9.81$, $p<.001$, in the two low altitude sector scenarios. Again, scores on these two queries were lowest in Scenario 3 (high altitude, high traffic volume). Awareness of which aircraft needed a new clearance in order to meet approach requirements was highest Scenario 3, however, $F(3,181)=10.38$, $p<.001$.

There was no difference between scenarios in participants' awareness of aircrafts' next sector, whether they were conforming to flight plan, aircraft separation, airspace violations, aircraft needing hand-offs, or aircraft communications.

As the results of the SA queries revealed a highly varied picture when each component is compared across scenarios, a multivariate ANOVA (MANOVA) was performed in order to determine whether these results were spurious. The MANOVA was significant, $F(57, 446)=3.119$, $p<.001$, indicating that these results are indeed significant and not the likely result of chance variation. Therefore it can be concluded that participants' situation awareness varied across the scenarios in a manner that reflects trade-offs in attention among the various SA components examined here.

Conclusions

This report documents the performance, perceived workload and situation awareness of a randomly selected group of controllers on four standardized air traffic scenarios. The scenarios were developed to include a range of traffic types and situations for both high altitude and low altitude sectors. These findings help to define the performance of controllers with the existing air traffic system so that any future changes in technology or operational concepts can be compared. By evaluating potential changes against the baseline of the current system, we can insure that the future air traffic control system meets or exceeds the current level of safety.

References

Endsley, M. R. (1995a). Measurement of situation awareness in dynamic systems. Human Factors, 37(1), 65-84.

Endsley, M. R. (1995b). Towards a new paradigm for automation: Designing for situation awareness. In Proceedings of the 6th IFAC/IFIP/IFOR/IEA Symposium on Analysis, Design and Evaluation of Man-Machine Systems . Cambridge, MA:

Endsley, M. R., & Kiris, E. O. (1995a). The out-of-the-loop performance problem and level of control in automation. Human Factors, 37(2), 381-394.

Endsley, M. R., & Kiris, E. O. (1995b). Situation awareness global assessment technique (SAGAT) TRACON air traffic control version user guide. Lubbock, TX: Texas Tech University.

Endsley, M. R., Mogford, R., Allendoerfer, K., & Stein, E. (1997). Effect of Free Flight Conditions on Controller Performance, Workload and Situation Awareness: A Preliminary Investigation of Changes in Locus of Control using Existing Technology. Lubbock, TX: Texas Tech University.

Endsley, M. R., & Rodgers, M. D. (1996). Attention distribution and situation awareness in air traffic control. In Proceedings of the 40th Annual Meeting of the Human Factors and Ergonomics Society (pp. 82-85). Santa Monica, CA: Human Factors and Ergonomics Society.

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), Human mental workload (pp. 139-183). Amsterdam: North-Holland.

Vortac, O. U., Edwards, M. B., Fuller, D. K., & Manning, C. A. (1993). Automation and cognition in air traffic control: An empirical investigation. , 7, 631-651.

Yeh, Y. Y., & Wickens, C. D. (1988). Dissociation of performance and subjective measures of workload. Human Factors, 30(1), 111-120.

Appendix A
Subjective Performance Evaluation Form

Job Function Category	Job Function	Satisfactory	Needs Improvement	Unsatisfactory
	1. Separation is ensured			
A. Separation	2. Safety advisories are provided			
	3. Awareness is maintained			
B. Control	4. Good control judgment is applied			
Judgment	5. Control actions are correctly planned			
	6. Positive control is provided			
	7. Prompt action to correct errors is taken			
	8. Effective traffic flow is maintained			
	9. Aircraft identity is maintained			
	10. Strip posting is complete/correct			
C. Methods &	11. Clearance delivery is complete/correct/timely			
Procedures	12. LOA's/Directives are adhered to			
	13. Additional services are provided			
	14. Rapidly recovers from equipment failures and emergencies			
	15. Visual scanning is accomplished			
	16. Effective working speed is maintained			
	17. Equipment status information is maintained			
D. Equipment	18. Computer entries are complete/correct			
	19. Equipment capabilities utilized/understood			
	20. Required coordinations are performed			
	21. Cooperative, professional manner is maintained			
	22. Communication is clear and concise			
E. Communication	23. Uses prescribed phraseology			
Coordination	24. Makes only necessary transmissions			
	25. Uses appropriate communications method			
	26. Relief briefings are complete and accurate			

Comments:

Appendix B
Remaining Actions Form

	Aircraft ID	N/A	Altitude changes required	Speed changes required	Accept hand-off	Initiate hand-off	Apprch clrance	Depart clrance	Freq chg	HO rejected or delayed	Dept. rejected or delayed
1											
2											
3											
4											
5											
6											
7											
8											

Appendix C
NASA-TLX

<u>Mental Demand</u>
How much mental and perceptual activity is required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Is the task easy or demanding. simple or complex, exacting or forgiving?

Low |————————————————| High

<u>Physical Demand</u>
How much physical activity is required (e.g., pushing, turning, controlling, activating. etc.)? Is the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?

Low |————————————————| High

<u>Temporal Demand</u>
How much time pressure do you feel due to the rate or pace at which the tasks or task elements occurred? Is the pace slow and leisurely or rapid and frantic?

Low |————————————————| High

<u>Performance</u>
How successful do you think you are in accomplishing the goals of the task? How satisfied are you with your performance in accomplishing these goals?

Good |————————————————| Poor

<u>Effort</u>
How hard did you have to work (mentally and physically) to accomplish this level of performance?

Low |————————————————| High

<u>Frustration</u>
How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent do you feel in performing the task?

Low |————————————————| High

Appendix D
Situation Awareness Global Assessment Technique Queries

(on the provided sector map)

1. Enter the location of all aircraft
   - aircraft in track control
   - other aircraft in sector
   - aircraft will be in track control in next 2 minutes

2. Enter aircraft callsign (for aircraft highlighted of those entered on sector map in query 1)

3. Enter aircraft altitude (for aircraft highlighted of those entered on sector map in query 1)

4. Enter aircraft groundspeed (for aircraft highlighted of those entered on sector map in query 1)

5. Enter aircraft heading (for aircraft highlighted of those entered on sector map in query 1)

6. Enter aircraft's next sector (for aircraft highlighted of those entered on sector map in query 1)

02	49	67
15	57	
16	58	
35	65	
landing in sector		

7. Enter aircraft's current direction of change in each column (for aircraft highlighted of those entered on sector map in query 1)

Altitude change	Turn
climbing	right turn
descending	left turn
level	straight

8. Enter the aircraft type (for aircraft highlighted of those entered on sector map in query 1)

9. Enter the aircraft's activity in sector (for aircraft highlighted of those entered on sector map in query 1)
   - en route
   - inbound to airport
   - outbound from airport

10. Which pairs of aircraft have lost or will currently lose separation if they stay on their current (assigned) courses?

11. Which aircraft have been issued clearances that have not been completed?

12. Did the aircraft receive its clearance correctly? (for each of those entered in query 11)

13. Which aircraft are currently conforming to their clearances? (for each of those entered in query 11)

14. Which aircraft will be handed off to another sector/facility in the next 2 minutes?

15. Enter the aircraft which are not in communication with you.

16. Enter the aircraft that will violate special airspace separation standards if they stay on their current (assigned) paths.

17. Enter the aircraft which are not conforming to their flight plan.

18. Which aircraft will need a new clearance to achieve landing requirements?

Appendix E
Instructions to Participants

This study is being conducted to measure workload, situation awareness and overall system performance when the existing air traffic control system is used. This data will be used as a basis of comparison to which future system design enhancements and automation concepts can be compared. (No data will identify you as an individual.)

During this study you will be asked to control traffic in each of two en route sectors: a low altitude sector and high altitude sector. At various times during the scenario, the simulation will be stopped and you will be asked some questions. These questions will relate to your understanding of what was happening in the scenario at the time of the stop.

You will also be asked to rate the workload that you were under. Rate your workload across the time interval from the prior stop to the current stop. The rating scales will be shown on a Macintosh computer adjacent to the ATC station.

Once you have completed both the queries and the workload scales, the simulation will be resumed from where you left off.

You will be provided with a practice trial that will allow you to experience filling out these queries. If you have any questions, please ask.

PARTICIPANT CONSENT FORM

I hereby give my consent for my participation in the project entitled:
Evaluation of the Baseline ATC System

I understand that the people responsible for this project are:
Dr. Carol Manning - FAA/CAMI (405) 954-6849
Dr. Mica Endsley - Texas Tech (806) 742-3543.

She has explained that these studies are a part of a project that has the following objectives:
To measure workload, situation awareness and overall system performance with the current ATC system

She or her authorized representative has: (1) explained the procedures to be followed, (2) described the attendant discomforts and risks, and (3) described the benefits to be expected.

The risks have been explained to me as follows: no risk present other than the usual stress experienced in controlling air traffic.

It has further been explained to me that the total duration of my participation will be no more than 8 hours in two sessions of 4 hours each.

There will be no direct payment to me for participation in this study beyond normal salary. There will be no effect on me, either directly or indirectly through my job, if I opt to withdraw from the study at any time.

Only Dr. Manning, Dr. Endsley, and their research assistants will have access to the records and or data collected for this study. All data associated with this study will remain strictly confidential and my identity will not be revealed in any way associated with this data. No data identifying individuals will be shown directly to ATC management or other personnel.

Dr. Manning or Dr. Endsley has agreed to answer any inquiries I may have concerning the procedures.

I understand that I will not derive any direct payment from participation in this study. I understand that I may discontinue this study at any time I chose without penalty. If any distress or discomfort occurs at any time, I will notify the study director.

Signature of Subject:______________________________ Date:____________

Signature of Project Director
or Authorized Representative:______________________________ Date:____________

Signature of Witness to
Oral Presentation:______________________________ Date:____________

Appendix F
SME SAGAT Data Evaluation Form

Subject ________ **Condition** ________ **Scenario** ________ **Trial** ________ **Stop number** ________

* if aircraft stays on current (assigned) path

	Aircraft	Track Control	Vertical velocity	Turning	Activity in Sector	Next Sector	Handed off in Next 2 Min	Not in comm with sector	Need new clearance to achieve landing req.	Will violate airspace sep. next 2 min*	Not conforming to flight plan
1		my control in next 2 min other in sector	level climbing descending	straight left right	en route in-bound out-bound						
2		my control in next 2 min other in sector	level climbing descending	straight left right	en route in-bound out-bound						
3		my control in next 2 min other in sector	level climbing descending	straight left right	en route in-bound out-bound						
4		my control in next 2 min other in sector	level climbing descending	straight left right	en route in-bound out-bound						
5		my control in next 2 min other in sector	level climbing descending	straight left right	en route in-bound out-bound						
6		my control in next 2 min other in sector	level climbing descending	straight left right	en route in-bound out-bound						
7		my control in next 2 min other in sector	level climbing descending	straight left right	en route in-bound out-bound						
8		my control in next 2 min other in sector	level climbing descending	straight left right	en route in-bound out-bound						

Which pairs of aircraft have lost or will lose separation in the next 2 minutes if they stay on their current (assigned) courses?

Which aircraft have assignments

(clearances that are not yet complete?)

	Received correctly?	Conforming to assigned clearance?
________	Y / N	Y / N
________	Y / N	Y / N
________	Y / N	Y / N
________	Y / N	Y / N
________	Y / N	Y / N